NGA AND BEYOND:

BUILDING A GEOSPATIAL INDUSTRY CLUSTER IN ST. LOUIS, MISSOURI

Office of the
MISSOURI MILITARY ADVOCATE

MISSOURI
Department of Economic Development

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In March 2016, the National Geospatial-Intelligence Agency (the "NGA") announced its selection of St. Louis, Missouri as the site of its new West campus ("N2W"), recommitting to its longtime home for generations to come. NGA chose St. Louis as the best place to conduct its mission of providing geospatial intelligence for U.S. national security efforts, and the State of Missouri (the "State") and local governments are committed to helping it do so. As NGA seeks deeper partnerships with private sector companies, it has a constantly growing need for skilled workers and innovative technology to ensure it can outpace global threats and equip the nation with the best geospatial intelligence in the world. To support NGA's mission, the State and St. Louis region must build on their vibrant geospatial industry ecosystem and increase their capacity to produce the talent and innovation needed to fuel the industry's rapid growth.

This document (1) highlights the St. Louis region's status as a "center of excellence" for the geospatial industry, (2) catalogs existing geospatial resources across the State, (3) identifies challenges to increasing the geospatial industry's growth in the St. Louis region, and (4) provides insights to strengthen and expand the geospatial industry ecosystem.

This document presents a statewide perspective and aims to serve as the first of several in-depth analyses of the St. Louis region's opportunity to further develop its geospatial industry cluster. Additional analyses needed include (1) a locally-driven set of economic development strategies, (2) a robust quantitative analysis of the region's current geospatial industry footprint, and (3) an independent, in-depth analysis of the geospatial industry with a recommended framework of strategies to support the geospatial industry ecosystem. Together, these documents can form the roadmap to firmly establish a globally recognized hub for the geospatial industry in the St. Louis region.

EXECUTIVE SUMMARY

- NGA selected St. Louis as N2W's home largely due to the State's and region's capability to provide the skilled workforce and innovative environment necessary to succeed in its mission. To fulfill this promise to support NGA's mission, the State and St. Louis region must work with fellow stakeholders to further develop a vibrant industry ecosystem capable of producing the additional talent and innovation necessary to fuel the geospatial industry's rapid growth.
- The geospatial industry significantly impacts the State economy, with NGA alone resulting in roughly $600 million in gross State product and 5,000 direct and indirect jobs. The industry is growing rapidly; it is projected to earn roughly $100 billion in revenue by the early 2020s. Some estimate that the geospatial industry already accounts for more than 500,000 direct and indirect jobs in the United States.
- The St. Louis region's current geospatial industry ecosystem exhibits most of the key traits seen in successful cluster initiatives across the country. However, a long-term, data-driven, overarching plan is necessary to optimize the cluster development opportunity. An in-depth, independent study and recommendations similar to the St. Louis region's successful development plan for the life science and plant science industry clusters would be a critical enabling step.
- The State and St. Louis region are rich in geospatial industry resources, including NGA and major industry and academic stakeholders. For instance, the State and St. Louis region's geospatial higher education resources include nearly 50 relevant courses, several research centers within the University of Missouri System, and a broad array of cross-disciplinary research and degree programs at St. Louis University, Washington University in St. Louis, and Southern Illinois University – Edwardsville. In addition, Missouri's local, State, and federal government leaders already demonstrated great interest in this industry cluster by working in an unprecedented fashion across geographic and political lines to convince NGA to select St. Louis as N2W's home.
- But simply winning the N2W decision is not enough to optimize an industry cluster in the St. Louis region. A number of stakeholders are implementing geospatial initiatives across the State and St. Louis region, but these stakeholders are sometimes unaware of others' efforts and resources. To avoid redundancy of initiatives and create a "rising tide" of concerted ecosystem development, geospatial stakeholders in industry, academia, and government must intentionally coordinate with each other.
- The St. Louis region has many geospatial resources and initiatives, but it needs a small group of dedicated individuals to step up as leaders to drive cluster development forward. These leaders would convey vision and coordinate stakeholders' efforts towards cohesive long-term cluster development.

SECTION I

THE OPPORTUNITY: GEOSPATIAL INDUSTRY AND CLUSTER OVERVIEW

The State and the St. Louis region have a unique opportunity to cultivate a globally recognized hub for the geospatial industry, akin to Kansas City's animal health corridor or St. Louis's plant and life science clusters. Developing a geospatial industry cluster could lead to significant long-term economic benefits for the State and St. Louis region, including business growth and job creation in the rapidly growing sector of geospatial technology.

What is the Geospatial Industry? The geospatial industry (broadly defined in this White Paper as location intelligence products and services), is incredibly broad and quickly evolving, touching everything from cell phone location services and 3D imagery to oil and gas exploration and smart city technology. Geospatial Media and Communications, a provider of international geospatial networking and knowledge-sharing platforms, breaks down the geospatial industry into four major technology segments:

- The first and largest segment, global navigation satellite system ("GNSS") and positioning, includes satellite determination of position, velocity, and time, an essential building block for the rest of the geospatial industry.[1] GNSS and positioning spans hardware and software for mobile phone mapping, precision agriculture (including Bayer, following its acquisition of Monsanto), satellite launches, surveying, indoor mapping, and service provision.
- The second segment, geographic information systems ("GIS") and spatial analytics, includes systems designed to capture, store, manipulate, analyze, and interpret data relationships, patterns, and trends.[2] Everyday applications for GIS and spatial analytics include city planning, utility management, retail and logistics, and disaster management.[3]
- The third segment, earth observation, is used to map the surface of the earth from air or space for a variety of potential uses.[4]
- The final segment, 3D scanning, is comprised of LiDAR, radar, and laser technology used to digitally capture virtual models of physical environments and their surroundings.[5] In the commercial sphere, 3D scanning is increasingly used in fields like architecture and engineering.[6]

Geospatial companies are often categorized as "defense" or "commercial". The segment descriptions above apply to both categories of companies, but those in the defense

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1 See Geospatial Media and Communications, *Geobuiz: Geospatial Industry Outlook & Readiness Index*, *2018 Edition* at 18 (hereafter referred to as the "Geobuiz Report").
2 See *id.* at 19.
3 See *id.*
4 See Geobuiz Report at 19.
5 See *id.* at 15, 19.
6 See *id.*

sector face unique challenges and opportunities when pursuing federal contracts. Defense companies provide geospatial products and services to federal agencies like NGA and other Intelligence Community agencies, which typically necessitates security clearances for employees, secure facilities to conduct classified work, and compliance with highly detailed federal procurement requirements. Commercial companies typically focus on a broader customer base for their products and services. However, defense and commercial companies are not mutually exclusive; many defense companies develop dual-use technologies by commercializing their work for non-defense customers, and many commercial companies regularly contract with federal agencies in addition to their non-government customer base.[7]

The Geospatial Industry Has a Large and Growing Place in the Global Economy. Geospatial services alone are projected to approach $100 billion in annual revenue by the early 2020s, and some estimate that at least 500,000 U.S. jobs are directly or indirectly related to the geospatial industry.[8] From 2013 to 2017, the geospatial industry grew at a compound annual growth rate ("CAGR") of 11.5%.[9] And the industry is projected to grow even faster through 2020, reaching a CAGR of 13.6%.[10]

In Missouri, the geospatial industry provides a significant economic impact. NGA's presence alone results in roughly $600 million in gross State product and 5,000 direct and indirect jobs.[11] Beyond NGA's impact, geospatial industry statistics are difficult to quantify. While most industries are distinguishable by NAICS and SIC codes, no such code exists for the geospatial industry. Due to the industry's nascent public awareness and extensive reach, geospatial industry statistics are typically included within broader categories (e.g. "All Other Computer Occupations") and lumped together with other tech jobs that may or may not be related.[12]

What is an Industry Cluster? Industry clusters are geographic concentrations of interconnected companies and institutions in a particular field. Clusters can form the basis of a vibrant local economy. Cluster theory champion Dr. Michael Porter of the Harvard Business School describes clusters' cycle of upward growth and momentum: "A growing cluster signals opportunity, and its success stories help attract the best talent. Entrepreneurs take notice, and individuals with ideas or relevant skills migrate in from other locations. Specialized suppliers emerge; information accumulates; local institutions develop specialized

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7 Interview with Steve Wallach, former NGA West Executive, and Steven Thomas, Advanced Systems Manager, Business Development, Ball Aerospace, Mar. 28, 2018.

8 See Jessica Sellers, *8 Mind-Blowing Facts About the U.S. Geospatial Industry*, Snaptrends, Feb. 24, 2016 (available at http://snaptrends.com/8-mind-blowing-facts-us-geospatial-industry/).

9 See Geobuiz Report at 4.

10 See Geobuiz Report at 11.

11 See University of Missouri Extension (EXCEED) and Entrepreneurship Ecosystems, LLC, *An Assessment of the Economic Impact of Military Spending in Missouri*, prepared for Office of the Missouri Military Advocate, Sept. 2018.

12 Correspondence with Missouri Economic Research and Information Center, Aug. 15, 2018.

training, research, and infrastructure; and the cluster's strength and visibility grow. Eventually, the cluster broadens to encompass related industries."[13]

Industry Cluster Identifiers. Industry clusters can be identified by (1) scale (i.e. the number/magnitude of local firms involved in the industry), (2) proximity between local firms, and (3) firms' interdependence on each other (i.e. firms gain a competitive edge from their proximity, whether through supplier relationships, joint research partnerships, or sharing a similar labor pool).[14] The St. Louis region's geospatial industry resources reflect these cluster identifiers and indicate potential for a targeted industry cluster.

Scale. St. Louis is the longtime and future home of NGA's West campus, home to one of the geospatial industry's most significant customers. NGA is a linchpin of national security, providing geospatial intelligence to the U.S. Department of Defense and Intelligence Community agencies and enabling critical national security actions and decisions.[15] Since 1952, NGA and its predecessor agencies have carried out significant portions of their mission in the City of St. Louis.[16] NGA's work affects everything from high-profile operations (e.g. the successful special operations raid on al Qaeda leader Osama bin Ladin's Pakistan compound, disaster relief efforts in Haiti and Puerto Rico) to supporting billions of GPS users on a daily basis.[17] Missouri is home to over 3,500 NGA employees at its St. Louis and Arnold campuses, comprising 26% of NGA's overall workforce.[18] Additionally, the St. Louis region is home to at least 40 companies operating in the geospatial industry, ranging from emerging companies like Boundless and Geodata IT to long-established companies like Boeing, Esri, and General Dynamics IT.[19]

Proximity. Geospatial companies' proximity to NGA is a unique benefit of the St. Louis region (apart from NGA's major presence in Springfield, Virginia) and enables frequent interactions and a shared labor pool. Additionally, contractors' proximity to each other provides ample opportunities for joint contract proposals and collaboration across large and small companies.[20]

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13 See Michael Porter, *Clusters and the New Economics of Competition*, Harvard Business Review, Nov. – Dec. 1998 issue.

14 See Ryan Donahue, Joseph Parilla, and Brad McDearman, *Rethinking Cluster Initiatives*, Metropolitan Policy Program at Brookings, Jul. 2018, at 17-18 (available at https://www.brookings.edu/research/rethinking-cluster-initiatives/) (hereafter referred to as the "Brookings Report").

15 See NGA Website, *About NGA* (available at https://www.nga.mil/About/Pages/Default.aspx).

16 See NGA, *Record of Decision: Next NGA Campus in the Greater St. Louis Metropolitan Area*, Jun. 2, 2016, at 2.

17 See NGA Website, *History* (available at https://www.nga.mil/About/History/Pages/default.aspx); see also NGA "By the Numbers" handout, received at conference with NGA and UM System, Jun. 29, 2018 (hereafter referred to as "NGA By the Numbers").

18 See *id.*

19 Presentation by Steven Thomas at St. Louis Geospatial Economic Development Workshop, May 4, 2018.

20 Interview with Steve Wallach, former NGA West Executive, and Steven Thomas, Advanced Systems Manager, Business Development, Ball Aerospace, Mar. 28, 2018.

Interdependence. The geospatial industry is highly interdependent on multiple levels. On a customer/vendor level, NGA is widely regarded as the geospatial defense sector's primary customer. NGA is a significant driver for the defense and commercial industries, and the agency has made clear that it will increase its partnerships with commercial companies in coming years. In August 2018, NGA released an updated Commercial GeoInt Strategy emphasizing its desire for a broad spectrum of products and services from commercial companies, including geospatial analytics, algorithms, and geo-referenced datasets.[21] On a peer company level, the federal contracting process is highly competitive but provides many opportunities for collaboration. Companies often coordinate joint RFP responses, complementing each other's skills and resources. And the benefits aren't limited to large companies – federal contracts typically require a minimum amount of small business involvement, creating many opportunities for emerging companies (often as subcontractors for a portion of the contract).[22]

Additionally, there is no established "hub" for the geospatial industry, and with strategic, long-term coordination and commitment from the State, St. Louis region, industry partners, academia, and other stakeholders, the St. Louis region could become a globally recognized hub for the geospatial industry as it is for the plant and life science industries.

Industry Cluster Key Traits. To capitalize on the opportunity to develop a geospatial industry cluster in the St. Louis region, the State and St. Louis region must foster an industry ecosystem capable of producing the innovation and talent necessary to fuel the geospatial industry's growth. Brookings specifies five key traits of the most successful industry cluster initiatives: [23]

- (1) Focused on establishing a robust ecosystem, not quick job gains;
- (2) Industry-driven, university-fueled, and government-funded;
- (3) Placed a collective big bet on a unique opportunity;
- (4) Championed by passionate, dedicated leaders; and
- (5) Anchored by a physical center.

These traits and their applicability to the State and the St. Louis region are discussed in more detail in Section II below.

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[21] See NGA, *Commercial GeoInt Strategy 2018 Update*, Aug. 2, 2018, at 1 (available at https://www.nga.mil/Partners/Pages/Commercial-GEOINT-Strategy.aspx)

[22] Interview with Steve Wallach, former NGA West Executive, and Steven Thomas, Advanced Systems Manager, Business Development, Ball Aerospace, Mar. 28, 2018.

[23] See Brookings Report at 6.

SECTION II

ANALYSIS: KEY CLUSTER TRAITS, EXISTING RESOURCES, NEEDS AND CHALLENGES, AND POSSIBLE SOLUTIONS

Missouri is home to many businesses, academic opportunities, and entrepreneurial resources capable of supporting the current and next generations of geospatial industry activity. However, much work remains in order to capitalize on the State's and St. Louis region's opportunity to cultivate a broadly recognized geospatial center of excellence. This Section explores: the five key traits of the most successful industry clusters; existing State and regional resources that contribute to the geospatial industry cluster initiative; needs and challenges that must be addressed in order to maximize the cluster opportunity; and potential action items for State and regional stakeholders to make the effort a success.

Trait 1: Focused on Establishing a Robust Ecosystem, Not Quick Job Gains

Broadly, a business ecosystem consists of a network of organizations involved in the delivery of a specific product or service through both competition and cooperation, in which each entity affects and is affected by the others, creating a constantly evolving relationship.[24] Ecosystem members include businesses, universities and research institutions, government agencies, and other individuals and organizations committed to supporting a particular industry.

Ecosystem development requires sustained, long-term investment across a variety of areas, most importantly supporting existing companies' growth and competitiveness. While economic development agencies typically use job creation as a key measure of success, cluster growth depends on a variety of metrics, some of which are extremely difficult to capture. For example, foundational cluster metrics include research output, grant awards, emerging company activity, talent development, export activity, and collaboration between stakeholders.[25]

Brookings describes five components relevant to industry ecosystem development:[26]

- (A) Information and networks (e.g. stakeholder knowledge of local industry activity and resources, investor knowledge of local firms and capabilities);
- (B) Talent development (including higher education, K-12, and other training initiatives);
- (C) Research and commercialization coordination;

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[24] See Investopedia, *Business Ecosystem* (available at https://www.investopedia.com/terms/b/business-ecosystem.asp)

[25] See Brookings Report at 34.

[26] See Brookings Report at 4-5.

- (D) Infrastructure and placemaking (e.g. research and training facilities, specialized equipment); and
- (E) Access to capital for emerging companies.

In 2018, Brookings highlighted these five components in St. Louis's ag science cluster and other successful industry clusters across the country.[27] As state and regional leaders consider options to support the geospatial industry, they should be mindful of successful precedent for these five components.

A. *Information and Networks*

A cluster cannot grow in a vacuum. Both internal and external stakeholders must know that the cluster exists, and stakeholders within the cluster must regularly interact with each other to benefit from a cluster's shared learning and development potential. Awareness of stakeholders' work, research, and resources enables collaboration and mutually beneficial relationships, including customer/vendor, employer/employee, and joint research and grant opportunities.

(i) Existing Resources

USGIF and SLAWG. Established in 2004, the not-for-profit United States Geospatial Intelligence Foundation ("USGIF") convenes representatives from industry, government, and academia to exchange ideas, share best practices, and promote the education and importance of the geospatial intelligence tradecraft.[28] USGIF has formed a number of topical working groups focused on particular areas of the geospatial tradecraft, ranging from machine learning and artificial intelligence to small satellite technology.[29]

To capitalize on NGA's selection of St. Louis for its new West campus and the region's significant amount of industry activity, local industry representatives worked with USGIF to establish the St. Louis Area Working Group ("SLAWG"). SLAWG is USGIF's first working group with a specific geographic focus, committed to creating educational and community pathways to geospatial degrees, certifications, and careers in the St. Louis region.[30] SLAWG focuses on amplifying NGA's ongoing training and education efforts, ultimately growing and sustaining "a populace within St. Louis and surrounding regions that possess the necessary geospatial skillsets to qualify for and fill existing and future NGA or industry technical, analytic and management careers."[31]

In just over one year of existence, SLAWG has raised awareness of the St. Louis region's geospatial resources and opportunities and convened a broad array of stakeholders

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27 See generally Brookings Report.
28 See USGIF website at https://usgif.org/about.
29 See USGIF website at https://usgif.org/community/Committees
30 See USGIF website at https://usgif.org/community/Committees/SLAWG.
31 See *id.*

from industry, government, and academia around the geospatial industry. Going forward, USGIF has indicated an ongoing interest in the St. Louis region's geospatial development and has offered its expertise and resources to help build regional infrastructure for geospatial education and training.

St. Louis Development Corporation. The St. Louis Development Corporation ("SLDC"), in addition to its efforts to prepare and deliver the N2W site for NGA's use, has played a leading role to convene local, regional, and statewide economic development organizations around the region's geospatial potential. With input from these stakeholders, SLDC plans to develop a comprehensive set of local economic development strategies to support NGA's mission and a geospatial industry ecosystem conducive to growth and innovation. Additionally, SLDC's Project Connect has made significant efforts to connect with community members living in the area immediately surrounding the N2W site in order to learn and address their needs as the area develops.

Missouri Department of Economic Development. The Missouri Department of Economic Development ("DED") is a State agency with the mission of encouraging economic growth by supporting Missouri's businesses and diverse industries, strengthening communities, developing a talented and skilled workforce, and maintaining a high quality of life.[32] DED offers broad resources for businesses seeking to grow in Missouri, ranging from financial incentives to assistance in areas like international trade and export. DED played a significant role in the NGA's decision to locate N2W in St. Louis, including a financing commitment of approximately $131 million.[33] Going forward, DED's resources and expertise could be a great help for geospatial companies hoping to grow their businesses in the State.

Missouri Military Advocate. The Office of the Missouri Military Advocate has played an active statewide role in foreseeing and responding to the need for geospatial ecosystem development to support NGA's mission. The Missouri Military Advocate has raised visibility of the State's growing geospatial industry amongst key military installations, State agencies, and academic partners to encourage and enable their active involvement in cluster development efforts.

Additional Economic Development Organizations. The Missouri Partnership, St. Louis Economic Development Partnership ("SLEDP"), and the St. Louis Regional Chamber provide valuable business support and recruitment services to the State and St. Louis region, and each organization has expressed its support for the St. Louis region's burgeoning geospatial possibilities. The Missouri Partnership provides business recruitment efforts for out-of-state companies to create jobs in Missouri, while SLEDP and the St. Louis

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[32] See DED website at https://ded.mo.gov/.

[33] See Nicholas J. C. Pistor, *National Geospatial-Intelligence Agency will stay in St. Louis*, St. Louis Post-Dispatch, Jun. 3, 2016 (available at https://www.stltoday.com/news/local/govt-and-politics/national-geospatial-intelligence-agency-will-stay-in-st-louis/article_a6aac4c9-052f-5fc2-8425-f5707d3fe87d.html).

Regional Chamber provide a broad host of business services ranging from startup accelerator programs to industry ecosystem support.

Tech Startup Ecosystem. St. Louis has aggressively encouraged startup activity and technological innovation through results-driven, effective programming. A broad host of innovation districts, funding resources, and accelerators fuel a robust startup scene and create skilled jobs. T-REX, a not-for-profit downtown technology incubator, has generated over 3,500 jobs, houses over 220 companies, and generates $465 million in annual economic output.[34] And the Cortex Innovation Community ("Cortex") has generated over $550 million in investment and over 4,500 jobs amongst 250 companies.[35] Along with the region's many other entrepreneur support organizations, these innovation centers played a vital part in convincing NGA to locate N2W in St. Louis.[36]

(ii) Needs and Challenges

Lack of Awareness about the Geospatial Industry. The geospatial industry suffers from low public awareness within the State and St. Louis region. Though many people in the State and St. Louis region are familiar with NGA following its announcement to locate N2W in St. Louis, few actually understand what the geospatial industry is and how much of it already takes place in Missouri. Though NGA and its predecessors have been in the region for over 60 years, until recently, NGA intentionally kept a low profile due to its classified work and highly secured facility. NGA's community outreach efforts following the N2W selection have been an important step, but much work remains to raise awareness of the geospatial industry's profile and potential in the State and St. Louis region.

External Awareness of the State and St. Louis Region. According to some, the regional geospatial industry suffers from negative national perceptions of the State and St. Louis region. Such perceptions were a key theme amongst geospatial and tech employers in the Tech Talent Supply Initiative (the "TTSI"), a joint effort between St. Louis University and Cortex to explore the St. Louis region's reported low supply of tech talent relative to local companies' hiring needs. TTSI participants expressed that negative perceptions of the St. Louis region, including crime statistics and race segregation, make it difficult to attract and retain geospatial and tech talent in the area.[37] The TTSI is discussed further in Trait 1, Section B(i) below.

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[34] See T-REX website at http://www.downtowntrex.org/about/.

[35] See Cortex website at https://cortexstl.com/who-we-are/; see also email from Aine O'Connor, Special Initiatives Lead, Cortex, Oct. 22, 2018.

[36] See, e.g., Jacob Barker, "*'Placing a Bet on St. Louis,' NGA Prepares to Allow More Access for Tech Firms It Hopes Will Cluster Here*," St. Louis Post Dispatch, Aug. 20, 2017 (available at https://www.stltoday.com/business/local/placing-a-bet-on-st-louis-nga-prepares-to-allow/article_8d9c40f5-f054-5825-b173-bb3d0c3218b4.html).

[37] St. Louis University and Cortex, *Tech Talent Supply Initiative Summary Report*, Jun. 2018 at 4 (hereafter referred to as the "TTSI Report").

However, some professionals in the industry located outside of Missouri have neither a negative nor positive impression of the State and the St. Louis area. Many industry professionals are aware that N2W will be located in St. Louis, but have little additional insight into the State or St. Louis region. For example, one longtime commercial tech provider who made his first trip to St. Louis to contract with NGA had a wonderful experience, leaving with a positive impression of the region.[38]

N2W's presence in St. Louis has the potential to attract talented individuals and geospatial businesses from outside the State, but the State and St. Louis region need to convey a strong, cohesive, positive brand in order to maximize talent and business recruitment efforts to a level capable of supporting a significant expansion of the geospatial industry.

(iii) Possible Solutions

In-Depth Study. A master framework is critical to fully capture and raise awareness of the St. Louis region's geospatial industry potential. This type of framework has precedent in the St. Louis region – St. Louis's successful plant and life science clusters are largely due to the implementation of a comprehensive, independent, qualitative and quantitative study released by Battelle in 2000 (the "Battelle Study"). The Battelle Study set forth a framework for the St. Louis region to capitalize on its existing resources and invest in new assets to form plant and life science industry clusters. Leaders from businesses, universities, State and local government, research facilities, and economic development organizations have coalesced around the study for nearly 20 years, resulting in successful projects such as the Missouri Technology Corporation and Cortex, as well as long-term investments in and growth of institutions like the Donald Danforth Plant Science Center.

A similar study for the geospatial industry would provide State and regional stakeholders with a shared understanding of the cluster development opportunity and an overarching framework to maximize the St. Louis region's potential as a globally recognized geospatial industry hub. Like the Battelle Study, the geospatial study should be comprehensive and include an economic analysis of the geospatial industry, current and future industry trends and opportunities, the St. Louis region's current standing compared to other regions with an industry presence, a SWOT analysis, specific strategies and recommendations for implementation (including strategies for business growth, business recruitment, and talent development, among other key areas), and benchmarking metrics to track progress.

An in-depth study needn't start from scratch – it could potentially build on quantitative and qualitative insight from several existing resources. DED's Missouri Economic Research and Information Center ("MERIC") produces large amounts of

[38] Interview with Sean Brophy, VP Sales: Government/Aerospace and Business Intelligence/Data Visualization, Mapbox, Sept. 12, 2018.

economic and workforce data on the St. Louis region and the rest of the State. SLDC's Geospatial Economic Development Workshop continues to leverage the collective experience of State and regional economic development organizations to develop actionable strategies for geospatial industry support and expansion. And industry-led organizations like USGIF and SLAWG may be able to collect and aggregate local and national industry data and trends to help guide development efforts.

B. *Talent Development*

All businesses need a steady stream of talented individuals to drive operations, and businesses within an industry cluster often need individuals with specific skill sets. For example, many positions within the plant and life science industries require at least a basic background in biology, and advanced positions often require specialized education and training. In the geospatial industry, basic and advanced geography and math skills are important, and broadly applicable tech skills such as coding, data science, and Dev/Ops (discussed below) are critical to the industry's rapid growth. K-12 education, higher education, and other training programs are key components of a comprehensive talent development pipeline for the geospatial industry.

(i) Existing Resources

Partners in Education Program and GeoPlunge Tournament. NGA is directly involved in geospatial education efforts through its Partners in Education Program (the "PIE Program"). The PIE Program is designed to promote geographic literacy, inspire STEM education, and advance students' GIS skills by linking NGA subject matter experts and volunteers with students, educators, and community leaders.[39] As of mid-2018, the PIE Program has collaborative relationships with over 70 schools in the St. Louis region.[40]

The PIE Program's principal initiative is its annual GeoPlunge tournament, which gives local fourth-graders an opportunity to learn about U.S. geography and compete against their peers in a geography-centric card game. To train for the tournament, NGA volunteers work with students nearly every day for six weeks to teach them how to play the game, helping them build basic geography skills in the process.[41] NGA's efforts led to tremendous results – after the six-week program, students' scores on before-and-after U.S. geography quizzes improved by an average of 40%.[42]

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[39] See NGA, *Waypoints: Partners in Education* at 3 (available at https://www.nga.mil/partners/academic_opportunities/pages/partners-in-education.aspx).

[40] Conference with NGA Partners in Education team and Missouri Department of Elementary and Secondary Education, Jun. 1, 2018.

[41] See Jessica Daues, *NGA co-hosts GeoPlunge tournament in St. Louis to promote geographic literacy*, Nov. 21, 2017 (available at https://www.nga.mil/MediaRoom/News/Pages/NGA-co-hosts-GeoPlunge-tournament-in-St--Louis-to-promote-geographic-literacy.aspx).

[42] See *id.*

Missouri Department of Elementary and Secondary Education. The Missouri Department of Elementary and Secondary Education's ("DESE's") Office of College and Career Readiness ("OCCR") has a number of existing programs that could be used to better inform Missouri educators and students about geospatial career opportunities. For example, DESE's Teacher Externship Program equips educators with hands-on learning opportunities by placing them in "job shadow" positions at partner organizations, resulting in educator-created curriculum based on their specific experiences. Additionally, OCCR regularly hosts events across the State to promote STEAM education and provide insight into various STEAM career paths.[43]

University Programs and Research. The State and St. Louis region are home to outstanding universities and colleges, many of which have geospatial courses and sponsored research to train the industry's current and future workforce.

University of Missouri System. The University of Missouri System (the "UM System") has a long history of geospatial programming and expertise across the State of Missouri. In 2007, the University of Missouri–Columbia ("UMC") earned USGIF's accreditation to offer geospatial intelligence certificates along with its traditional degree programs.[44] USGIF accreditation reflects that a university's curriculum matches the knowledge and skills requirements of the professional workforce, signaling to employers that students with certificates are ready to jump into geospatial work immediately upon graduation.[45] UMC's geospatial intelligence certificate program provides broad-based courses on foundational materials for GIS and remote sensing ("RS"), along with advanced elective courses in more specific areas like image processing and spatial analysis.[46] Additionally, the UM System offers certificate programs in the fields of data science, geography, and big data analytics.[47]

The UM System houses several geospatial-focused facilities and offers nearly 50 courses related to geospatial disciplines.[48] First, the UMC Department of Geography's Geospatial Resources Center ("GRC") is a multidisciplinary applied research and teaching facility for GIS and RS data analysis, complete with specialized analysis and production cartography equipment.[49] The GRC offers classes, workshops, and customized training in numerous GIS and RS fields, including digital

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43 Conference with NGA Partners in Education team and Missouri Department of Elementary and Secondary Education, Jun. 1, 2018.

44 See USGIF website at https://usgif.org/education/accreditation *and* https://usgif.org/education/accreditation/1-university-of-missouri.

45 See USGIF website at https://usgif.org/education/accreditation.

46 See University of Missouri Department of Geography website at https://geography.missouri.edu/gip.

47 Conference with NGA and UM System, Jun. 29, 2018.

48 List of geospatial-related courses provided by Dr. Mark McIntosh, Vice President, Research and Economic Development, UM System, Sept. 6, 2018.

49 See GRC website at http://www.grc.missouri.edu/; see also GRC website at http://www.grc.missouri.edu/facilities.html.

image processing, GIS analysis and management, database design, system planning and design, and computer cartography.[50] Second, UMC is home to the Center for Geospatial Intelligence ("CGI"), a multimillion dollar research facility housing specialized research labs focused on geospatial intelligence and national defense.[51] CGI has incorporated 21 faculty members from various academic disciplines to collaborate on projects including satellite RS, target recognition, data processing and production, automated feature extraction, pattern recognition, intelligent databases, and the detection and characterization of underground structures.[52] The CGI's research has garnered approximately $18 million in awarded proposals.[53]

The UM System has a history of supporting NGA's mission. In 2016, NGA announced a $12 million contract awarded to UMC's School of Engineering for training NGA employees in data science and "key education and training needs identified by NGA."[54] In addition to online coursework, UMC professors teach in-person geospatial classes in St. Louis, and UMC has contracted for teachers in Washington, D.C. to support NGA's East Campus workforce. Additionally, UMC is one of only three U.S. academic institutions that has an Educational Partnership Agreement with the NGA, under which UMC routes its students into NGA internships.[55]

St. Louis University. St. Louis University ("SLU") has a broad array of geospatial capabilities across academic disciplines, as well as potential plans to scale up the university's geospatial focus. SLU faculty conduct geospatial research in many areas, including a robust RS lab, disaster relief, public health, energy resources, food and water security, urban planning, and crime analysis.[56] SLU has established a research relationship with Ameren relating to geospatial applications for energy resources, and researchers are actively seeking out additional research partnerships, including several potential projects with NGA.[57]

As part of a university-wide research enterprise competition, SLU has identified geospatial research as a potential focal point for growth and investment. The proposal envisions the SLU Geospatial Research, Training, and Innovation Enterprise (the "GeoSLU Initiative"), a consortium of faculty and students focused

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50 See GRC website at http://www.grc.missouri.edu/pands.html.
51 See University of Missouri Department of Geography website at https://geography.missouri.edu/gip.
52 See University of Missouri College of Engineering website at https://engineering.missouri.edu/research/research-centers/geospatial-intelligence-lab/.
53 See *id.*
54 See Ashley Jost, *Mizzou wins $12 million, 5-year contract to train NGA employees in St. Louis, Washington*, St. Louis Post-Dispatch, Sept. 1, 2016 (available at https://www.stltoday.com/news/local/education/mizzou-wins-million--year-contract-to-train-nga-employees/article_2022ae99-f313-5304-ad62-61ee1cb2bf1d.html).
55 See University of Missouri Geography Department website at https://geography.missouri.edu/gip.
56 Interview with Dr. Mark Brickhouse and Dr. Vasit Sagan of SLU, Aug. 10, 2018.
57 *Id.*

on promoting and developing geospatial disciplines across their various academic disciplines, ranging from civil and mechanical engineering to biology and epidemiology.[58] According to Dr. Mark Brickhouse, SLU's advisor for geospatial research and training, the GeoSLU Initiative will consist of three core elements: (1) research to apply geospatial insights to important regional and global challenges, with a focus on externally funded grants; (2) data support services to provide geospatial analytics and data management to faculty and students engaged in geospatial research; and (3) teaching and training services in graduate and undergraduate education and additional workforce development opportunities in basic and advanced geospatial techniques and methods.[59] To further the GeoSLU initiative, the SLU team would pursue partnerships and grant opportunities with other universities and federal agencies such as NGA, the National Science Foundation, the National Institutes of Health, NASA, the U.S. Department of Defense, the U.S. Department of Energy, the U.S. Geological Survey, the U.S. Environmental Protection Agency, and the National Oceanic and Atmospheric Administration.[60]

SLU has a broad array of geospatial research and training resources and opportunities, and the GeoSLU Initiative, if selected for further growth and investment, would provide great opportunities to further the State's and St. Louis region's geospatial industry capabilities.

Washington University in St. Louis. Washington University in St. Louis ("WUSTL") offers a certificate in GIS for working professionals and full-time students and occasionally hosts adjunct faculty from NGA.[61] WUSTL's Department of Anthropology contains the Spatial Analysis, Interpretation and Exploration laboratory ("SAIE Lab"), which incorporates GIS to better understand human societies over time and across geographic space.[62] SAIE Lab researchers "use a variety of related technologies to map, analyze, reconstruct, interpret, and explore how spatial and temporal aspects of human landscapes condition and affect history and society around the world."[63] WUSTL also incorporates geospatial analysis in research on public health, social work, big data analytics, environmental studies, engineering, atmospheric science, and Mars.[64]

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58 See Dr. Mark Brickhouse, *GeoSLU White Paper: Growing the Geospatial Research, Training, and Innovation Enterprise at Saint Louis University*, May 29, 2018.

59 See *id.*

60 See *id.*

61 See WUSTL 2018-19 Bulletin, *Geographic Information Systems*, available at http://bulletin.wustl.edu/undergrad/ucollege/cert-geographic-info/. Conference with NGA and UM System, Jun. 29, 2018.

62 SLAWG R&D Subcommittee White Paper, May 29, 2018.

63 See *id.*

64 Interview with Aaron Addison, Director of Collaborative Research and Data/GIS, WUSTL, Aug. 21, 2018

Southern Illinois University – Edwardsville. Southern Illinois University - Edwardsville ("SIUE") offers a geography undergraduate degree program with opportunities to minor in GIS/Cartography.[65] SIUE also conducts geospatial research in the fields of agriculture, climate change, public health, RS, digital elevation modeling, spatial statistics, and earth observation.[66]

Internships. Geospatial industry internships are available for college students. For example, NGA has an established internship program that often results in offers of full-time employment following graduation.[67] The UM System has provided NGA with a pipeline of interns over the years, including 14 interns in 2018.[68] Geospatial companies have internship programs as well, though the practice varies from company to company. For example, Raytheon has partnered with the UM System to create the MU-Raytheon National Defense Fellowship, a recruiting pipeline for undergraduate computer science students that provides them with a guaranteed internship, $10,000 bonus, security clearance, and guaranteed job following graduation, conditioned on working at least two years for Raytheon.[69]

Missouri Division of Workforce Development. In addition to traditional education resources, the State and St. Louis region have long-established training resources for the current workforce. The Missouri Department of Economic Development's ("DED's") Division of Workforce Development ("DWD") works with federal, state, and local partners to support local workforce development boards, staff a statewide network of 31 full-service job centers, and disburse funding for local workforce development initiatives.[70] DWD also partners with Missouri's statewide community college network to administer the State's Skilled Workforce Missouri program, which offers customized job training programs for specific industries and companies, an industry-responsive resource that equips Missouri job seekers with the skills employers need.

DWD does not currently have a geospatial-focused career pathway, but its existing statewide job training infrastructure could potentially serve as a conduit to meet talent development needs of geospatial-focused employers.

LaunchCode. St. Louis is home to LaunchCode, a tech training center focused on providing coding education, job training, and apprenticeship job placements to help meet

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See SIUE Department of Geography website at https://www.siue.edu/artsandsciences/geography/gis_cartography.shtml.

66 Email from Dr. Susan E. Hume, Chair of the Department of Geography, SIUE, Oct. 29, 2018.

67 See NGA website at https://www.nga.mil/Careers/StudentOpp/Pages/default.aspx.

68 Conference with NGA and UM System, Jun. 29, 2018.

69 Presentation by Dr. Curt Davis, Director of CGI, at UM System Geospatial Summit, Oct. 4, 2018.

70 See Jobs.mo.gov, *Missouri Workforce System* (available at https://jobs.mo.gov/community/mo-workforce-system).

the growing demand for tech talent.[71] LaunchCode has placed 980 participants in tech-based careers since 2013 and provided some form of training to nearly 4,500 participants.[72]

On the geospatial front, LaunchCode has partnered with NGA to develop new curriculum around geospatial skills to provide "new people a new pathway to tech jobs" that will be available at N2W.[73] The partnership has resulted in a training program for newly hired NGA developers and coders from various backgrounds and experience levels to build "a baseline knowledge in [GIS] mapping technology," with two classes of employees graduated by the end of June 2018.[74] Additionally, LaunchCode has partnered with Booz Allen Hamilton ("BAH") to train veterans for tech-centric jobs in the geospatial sector. BAH hires the veterans, pays their program fees, and gets trained employees who already hold security clearances from their military service – a win for all parties involved.[75]

Tech Talent Supply Initiative. SLU and Cortex coordinated the Tech Talent Supply Initiative ("TTSI"), an effort to learn the causes and effects of the St. Louis region's need for increased tech talent relative to local companies' hiring needs. The TTSI consisted of several focus group discussions involving top local companies (e.g. World Wide Technology, Mallinckrodt, Ascension, RGA), university representatives (e.g. SLU, WUSTL, Lindenwood University, Webster University, St. Louis Community College, and SIUE), innovation leaders (e.g. Danforth Plant Science Center, Cortex, ITEN), and training program coordinators (e.g. LaunchCode, Midwest Cyber Center). The focus group discussions provided qualitative confirmation of the need for increased tech talent in the St. Louis region, recurring themes pinpointing different aspects of the need, and potential next steps that could help address the need. Cortex and SLU plan to continue the TTSI and convene industry, academia, innovation, and government stakeholders around the shared goal of increasing the region's tech talent.[76]

(ii) Needs and Challenges

Need for University Coordination. The State's higher education community is rich in geospatial research and resources, but greater coordination is needed to optimize their geospatial capabilities. At present, few inter-university connections exist between geospatial faculty, programs, and resources at the UM System, SLU, WUSTL, SIUE, or other schools. Though the universities have valuable geospatial curriculum and resources, some are not

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71 See LaunchCode website at https://www.launchcode.org/about.

72 See LaunchCode, *2017 Annual Impact Report* (available at https://www.launchcode.org/annualreport/2017).

73 See Kristin Quinn, *Geospatial Growth in St. Louis*, Trajectory Magazine, Nov. 7, 2017 (available at http://trajectorymagazine.com/geospatial-growth-st-louis/).

74 See Jessica Daues, *NGA new hires graduate from LaunchCode*, Jun. 29, 2018 (available at https://www.nga.mil/MediaRoom/News/Pages/NGA-new-hires-graduate-from-LaunchCode.aspx); see also NGA website, *NGA developers graduate from LaunchCode*, Jun. 27, 2018 (available at https://www.nga.mil/MediaRoom/PressReleases/Pages/NGA-developers-graduate-from-LaunchCode.aspx).

75 Interview with Eric Druker, Director of Artificial Intelligence, BAH, Sept. 4, 2018.

76 See TTSI Report.

aware of other universities' efforts and capabilities. Lack of coordination between universities could lead to duplicative efforts or needless competition, but increased collaboration and communication could mitigate these risks.

Security Clearance Backlog. Virtually every defense company that contracts with NGA needs workers with security clearance. Due to the national security implications of NGA's work, most of its contracts require contractors with security clearance for any workers on the project. The clearance process takes an excruciatingly long time, typically over a year. Geospatial companies must account for these delays when hiring workers and planning contract proposals. For example, NGA has several employees doing unclassified work at T-REX as they await their clearances, and some geospatial companies may have unclassified contract work suitable for employees awaiting clearances. But without a steady supply of unclassified work, geospatial companies may have difficulty profitably staffing workers before they receive their clearances.

Need to Increase K-12 Awareness and Develop Curriculum. NGA's initial community outreach has been a positive step, but additional efforts are necessary to raise awareness of the geospatial industry amongst students, teachers, and administrators across K-12 systems. Most schools are unaware that the industry exists, resulting in low-to-no visibility for students or teachers. In Missouri, school districts are largely autonomous entities in control of their own curriculum and programs. Without local school district support, it is very difficult to introduce new curriculum or career education in K-12 schools.

Currently, geospatial careers are not included amongst the State's recognized career paths and clusters, a primary gateway to career visibility amongst students and teachers.[77] Without student and teacher awareness of geospatial careers, the State and St. Louis region will have difficulty supplying future talent for NGA and other geospatial employers. And beyond the awareness gap, the State lacks geospatial-focused curriculum to introduce geospatial skills at the K-12 level.

Need to Increase Internship Connections. SLAWG meetings and TTSI focus groups have noted the lack of a clear process to identify and publicize geospatial industry internships among students. On the supply side, students are largely unaware of such internships, and on the demand side, geospatial employers lack a streamlined method to identify and recruit promising internship candidates. Though NGA has an established internship program and recruitment process, it is difficult for some geospatial employers to find and hire qualified interns from Missouri institutions.[78]

Need to Increase Geospatial Training Opportunities. There is no statewide or local workforce development program tailored for the geospatial industry. Though training

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[77] See DESE Career Path and Cluster chart, available at https://dese.mo.gov/sites/default/files/MO_Career_Clusters_poster_17x22-Web.pdf.

[78] Matt Ashley of BAH, presentation at Feb. 2018 SLAWG meeting.

organizations like LaunchCode have proven models for teaching skills necessary for coding and cybersecurity, both of which are in high demand from geospatial employers, their training programs are simply too small to train enough people – according to the TTSI, there are thousands of open tech positions in the St. Louis region every year.[79] Existing tech training programs work well, but would need to be majorly scaled up to meet industry needs.[80]

Need to Increase Dev/Ops Training. Development/Operations ("Dev/Ops") is a highly valued skillset in geospatial and other tech-centric industries, and there are no formal Dev/Ops training opportunities in the St. Louis region. Dev/Ops is a combination of "philosophies, practices, and tools that increases an organization's ability to deliver applications and services at high velocity: evolving and improving products at a faster pace than organizations using traditional software development and infrastructure management processes."[81] Dev/Ops is a critical skill to maximize efficiency and customer responsiveness in startups and established companies alike, and it suffers from high demand and low supply of trained professionals in the St. Louis region.[82]

(iii) Possible Solutions

Convene a Recurring Higher Education Geospatial Roundtable to Coordinate University Programs and Resources. The State's universities should collaborate with each other to create awareness of each institution's existing resources and identify opportunities for joint research, grant proposals, course reciprocity across institutions, and shared facilities and equipment. Coordination of universities' geospatial efforts could create a rising tide that would benefit all academic stakeholders, as well as the broader geospatial ecosystem. Particularly, a recurring roundtable discussion between universities' geospatial point persons would help build awareness, identify joint opportunities, and build a networked community at the cutting edge of geospatial research. Thus far, the UM System has conducted one such roundtable between three of its campuses and NGA, industry representatives, innovation leaders, and State and local government officials; this roundtable provided useful insights into potential links and collaboration opportunities between them.[83]

Recognize Geospatial Career Pathways at the State Level. DESE and the State Board of Education should strongly consider identifying geospatial as a recognized career pathway. Student awareness and interest in geospatial careers must begin at an early age, and

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79 See TTSI Report.
80 See *id.*
81 See Amazon Web Services, *What is DevOps?* (available at https://aws.amazon.com/devops/what-is-devops/).
82 Interview with Andy Dearing of Boundless, Jun. 15, 2018; see also TTSI Report.
83 UM System Geospatial Summit, Oct. 4, 2018.

recognizing geospatial careers at the State level would be an important first step to increasing awareness and interest.[84]

Integrate Geospatial Career Paths into Existing DESE/OCCR Programs. At a State-facilitated meeting between DESE, NGA, and USGIF, DESE Assistant Commissioner Dr. Blaine Henningsen noted that OCCR's Teacher Externship Program could easily extend to geospatial industry partners.[85] Exposing teachers to geospatial career paths would be a critical step toward developing geospatial-focused curriculum. Additionally, OCCR regularly hosts events across the State to promote STEAM education and provide insight into various STEAM career paths. OCCR has indicated that it would gladly incorporate NGA and geospatial career paths into these events.[86] Doing so would provide the State's teachers and students with a better understanding of geospatial career opportunities within the State.

Increase Visibility Among Local School Districts. DESE maintains strong relationships with school districts throughout the State. Each school district is largely responsible for its own curriculum, but DESE can be a key player in conveying vision and providing resources to the districts, including curriculum and promotional materials detailing potential career paths. DESE should make an intentional effort to inform school district superintendents of promising geospatial career paths and encourage creative ideas for curriculum and industry exposure for teachers and students.

Identify Skills Necessary for Geospatial Careers. To guide geospatial education and talent development efforts across the State and St. Louis region, stakeholders from industry, workforce development organizations, and academia should collaborate to identify the core foundational skillsets necessary for geospatial careers. After skills are identified and documented, a cross-sector group representing industry, K-12 education, higher education institutions, and training organizations could determine when each skill set should be introduced in order to coordinate existing resources and, ultimately, meet geospatial employers' needs. A potential starting point – the Geospatial Technology Competency Model, an educational framework created by the U.S. Department of Labor's Employment Training Administration, the GeoTech Center, and industry subject matter experts, identifies basic skills that should be built into an overarching geospatial education strategy.[87]

Hold Geospatial Classes, Training, and Certification Programs at a Centralized Location. Holding courses and training programs at a central location would make it easier for individuals to build geospatial skillsets and open doors to good-paying jobs

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84 Meeting with DED, DESE, and SLAWG, Feb. 21, 2018.
85 Conference with NGA PIE Program team, DESE, and USGIF, Jun. 1, 2018.
86 See *id.*
87 See U.S. Department of Labor – Employment and Training Administration and GeoTech, *Geospatial Technology Competency Model*, available at https://www.careeronestop.org/competencymodel/competency-models/geospatial-technology.aspx.

at NGA and throughout the industry. For example, T-REX's Geospatial Resource and Innovation Center ("GRIC") will house classrooms where regional universities can hold geospatial-centric classes and training.[88] T-REX is already in discussion with the UM System to offer some of its geospatial curricula in GRIC, and GRIC would be available for other universities' courses as well. GRIC's layout and central location will enable proximity between industry and higher education partners, which could lead to increased information and talent flow that would further support ecosystem development. GRIC is further discussed in Trait 1, Section D(i) below.

Create Dev/Ops Curriculum or Training Program. To address the specific need for homegrown Dev/Ops talent, industry representatives should work with universities and community colleges to design a Dev/Ops curriculum within the State and St. Louis region. Alternatively, industry representatives could collaborate with existing training organizations like LaunchCode or Midwest Cyber Center to design and implement a Dev/Ops training program.

C. *Research and Commercialization*

Industry clusters thrive on innovation, which typically requires robust research capabilities and the means to translate research findings into commercially viable products and services. Specifically, Brookings describes a need for "research activities intent on solving a specific industry problem that can be translated into commercial activity."[89] For example, St. Louis's plant and life science clusters thrive on a system of "basic research, applied research, and entrepreneur-led commercialization."[90] These capabilities are crucial to growing startups and creating the innovations necessary to fuel the constantly evolving geospatial industry.

(i) Existing Resources

Industry Research. The St. Louis region is home to a significant amount of industry R&D. According to a series of interviews conducted by the SLAWG R&D Subcommittee, ongoing industry research in the St. Louis region includes:[91]

- Imagery analysis and full motion video analysis for machine learning innovation;
- Management and analysis of extremely large datasets, along with dynamic and feature data analysis;
- Solving organizational design difficulties that otherwise make data coordination difficult or impossible;

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88 Note: As of this White Paper's publication date, T-REX had not yet finalized the GRIC's official name.
89 See Brookings Report at 27.
90 See *id.*
91 SLAWG R&D Subcommittee White Paper, May 29, 2018.

- Human geography issues to accurately forecast world events from a geospatial perspective;
- Developing "conflation tools" to connect data across platforms and utilities;
- Generating coherent information and applications for pilots and aeronautics;
- 3D maritime imagery and dataset connection; and
- Big data analysis and comparison.

NGA Academic Research Programs. The NGA Academic Research Program ("NARP") supports geospatial research in a variety of ways. NARP supports NGA's mission by awarding academic grants to leading investigators at universities and colleges across the nation, hiring visiting scientists who are domain experts to perform research (onsite or offsite) in response to research requirements, and supporting undergraduate research in the geospatial sciences at the military service academies.[92]

Through the NARP's Visiting Scientist Program ("VSP"), NGA hires leading scientists and specialists to conduct research "relating to the theory, observation, analysis, and modeling of geospatial intelligence (GEOINT) technologies, processes and methodologies".[93] NGA provides VSP scientists with equipment, data, data services, and a monthly stipend for periods ranging from six months to five years.[94] The VSP currently hosts 13 scientists, including 2 at NGA's St. Louis campus.[95]

The NARP provides researchers with two- to five-year grants to further their work in geospatial information sciences, physics, mathematics, statistical forecasting, geography, computer science, visual cognition, data science and data analysis, computational modeling, human computer interaction, astrophysics, and remote sensing.[96]

University Research and Tech Transfer. The State's universities are rich in geospatial research, ranging from defense-oriented geospatial intelligence to everyday applications of geospatial technology. Table 1 below provides examples of university research across the State and St. Louis region. Additionally, the UM System, SLU, WUSTL, and SIUE each have a tech transfer office to help students and faculty commercialize promising intellectual property.[97] Of particular note, the UM System has an incredibly

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92 See NGA Academic research program website, available at https://www.nga.mil/partners/researchandgrants/pages/academicresearchprogram.aspx.

93 See NGA Research, Visiting Scientist Program Informational Brochure, available at https://www.nga.mil/partners/researchandgrants/pages/academicresearchprogram.aspx.

94 See *id.*

95 Christine Woodard of NGA, presentation at UM System Geospatial Summit, Oct. 4, 2018.

96 See NGA Research program website at https://www.nga.mil/partners/researchandgrants/pages/academicresearchprogram.aspx).

97 See UM System website at https://research.missouri.edu/otmir/, SLU website at https://www.slu.edu/research/faculty-resources/research-innovation-group/index.php, WUSTL website at https://otm.wustl.edu/, and SIUE website at http://siusystem.edu/tech-transfer/.

commercialization-focused tech transfer policy that lets industry partners own all intellectual property rights, subject to certain investment thresholds and principal investigator consent.[98]

Table 1 – University Geospatial Research

UM System	**SLU**
• Remote sensing • GIS • Satellite remote sensing • Target recognition • Data processing and production • Automated feature extraction • Pattern recognition • Intelligent databases • Detection/characterization of underground structures	• Remote sensing • Disaster relief • Public health/epidemiology • Energy resources • Food and water security • Urban planning • Crime analysis
WUSTL	**SIUE**
• Public health/epidemiology • Big data analytics • Anthropology • Urban planning • Environmental studies • Atmospheric research	• Agriculture • Climate change • Public health • Cartography/web-based mapping • GIS and remote sensing • Digital elevation modeling • sUAS environmental modeling • Spatial and social network analysis • Spatial statistics • Modeling Earth's Critical Zone

(ii) Needs and Challenges

Data Availability. Research cannot happen in a vacuum – it's all derived from data, especially in the geospatial industry. Geospatial research depends on access to data, whether in the form of satellite images, video feed, or otherwise. Data enable researchers to analyze their meaning, monitor changes, evaluate trends and patterns, and produce usable guidance for military, government, and corporate decision-makers, among others. Though a vast

[98] Presentation by Dr. Mark McIntosh, Vice President, Research and Economic Development, UM System, UM System Geospatial Summit, Oct. 4, 2018.

amount of closed- and open-source data exists, links between industry, academia, and NGA are vital to ensure data's effective application.[99]

Increased Need for Computing Power, Data Storage and Analytical Capabilities. Geospatial data are massive, and the industry requires expensive equipment and rapid technological evolution in order to effectively use it.[100] There are roughly 44 zettabytes (i.e. 44 trillion gigabytes) of geospatial data on the horizon, and the geospatial industry faces significant challenges to increase its capabilities "to analyze data using enhanced technology platforms (artificial intelligence, machine learning and cybersecurity networks); and for training and deploying data scientists who are able to apply advanced computational methods such as modeling, social network analysis, [GIS], and deep learning algorithms to analyze and understand physical and human geographic behaviors."[101] Without rapid technological advances, effective geospatial research and development will face great difficulties.

(iii) Possible Solutions

Broker Data-Sharing Partnerships. A coordinating body could forge data-sharing partnerships between local big data producers and solutions-focused data-users in industry and academia.[102] For example, St. Louis-based Enterprise Holdings, Inc. collects massive amounts of geospatial data on its many fleet vehicles, and Bayer (formerly Monsanto) has troves of data on precision agriculture and growing patterns around the world. A neutral third-party could serve as a brokerage or clearinghouse for such data producers to safely share their data and allow access to emerging companies and academic researchers to identify key geospatial trends and generate real-world solutions to industry problems. T-REX's GRIC could be an ideal broker to help forge these relationships, amplifying its aim to unite geospatial professionals from industry, academia, and beyond. GRIC is discussed further in Trait 1, Section D(i) below.

Launch Geospatial Demo Days for Companies and Universities to Showcase Research and Interact. Demo days are "the culmination of accelerator programs" in which "[c]ompanies, investors, mentors and the community come together to review the progress that companies made and to celebrate their hard work."[103] Though demo days are typically designed to pitch companies to investors, the concept could easily be repurposed to help geospatial stakeholders share their products, services, and research with fellow stakeholders and the broader community, thus generating interest and awareness. Such an event could help break down the siloes between defense, commercial, and academic

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99 See T-REX, *Supporting Geospatial Innovation and Entrepreneurship in St. Louis Missouri*, Aug. 2018.
100 Interview with Eric Druker, Director of Artificial Intelligence, BAH, Sept. 4, 2018.
101 See T-REX, *Supporting Geospatial Innovation and Entrepreneurship in St. Louis Missouri*, Aug. 2018.
102 Interview with Eric Druker, Director of Artificial Intelligence, BAH, Sept. 4, 2018.
103 See Alex Iskold, *7 Tips for Crushing It at Demo Day*, Entrepreneur.com, May 27, 2015 (available at https://www.entrepreneur.com/article/246598).

stakeholders, though classified work would require heightened security and a smaller audience.

Encourage Greater Use of NGA's Academic Research Programs. Currently, NGA's St. Louis campus has few scientists engaged in the VSP or other NARP initiatives. State and regional universities should encourage their geospatial- and STEM-centric faculty and students to take advantage of these programs to further develop promising research opportunities and foster closer working relationships between NGA and the higher education community.

Provide Support for Collaborative Early-Stage Geospatial Research. Dedicated resources and possible seed funding could help initiate promising early-stage collaborative geospatial research. A base model comes from SLU's faculty summer research program, in which faculty receive small grants to fund "proof of concept" projects and initial datasets that can be leveraged to bolster their competitiveness for larger, nationally-competitive research grants.[104] A geospatial research program could provide office space, equipment use, and possible "seed stage" funding for promising geospatial research. Additionally, this program could be conditioned on a research partnership between a combination of stakeholders from different universities, geospatial companies (whether emerging or established), or government in an effort to leverage stakeholder resources and expertise and build cross-sector relationships across the geospatial ecosystem.

D. *Infrastructure and Placemaking*

Industry clusters typically require specialized infrastructure and real estate in order to carry out operations, research, and development. Examples include greenhouses and wet labs for the plant science industry, easy access to water for Milwaukee's water technology industry, and large tracts of empty land for testing drones in Syracuse's unmanned aerial system industry.[105]

The geospatial industry is no exception. Geospatial work often requires sophisticated equipment to process and visualize data, as well as server farms capable of storing massive amounts of data. The industry is broad enough that many of its sectors may have additional nuanced needs. Additionally, clusters are typically stronger when concentrated in a physical "center", such as St. Louis' 39 North District for ag tech or South Carolina's CU-ICAR campus for automotive technology.[106] Physical "centers" are discussed further in Trait 5 below.

(i) Existing Resources

[104] Interview with Patty Hagen, President and Executive Director, T-REX, Sept. 28, 2018.
[105] See Brookings Report case studies on St. Louis, Milwaukee, and Syracuse (available at https://www.brookings.edu/research/rethinking-cluster-initiatives/).
[106] See Brookings Report at 28.

N2W. Upon its completion in 2024, N2W will serve as a focal point for the State and regional geospatial industry. Most of the 97-acre campus will be reserved for classified work, but NGA plans to devote 20% of its future space to flexible work and 20% to sensitive but unclassified work, making it more accessible to industry and academic research partners. NGA also hopes to reserve some publicly accessible space in the N2W campus within the scope of federal security requirements.[107]

University Geospatial Infrastructure. The State's and region's universities have significant facilities and equipment for geospatial research, including UMC's GRC and CGI and SLU's comprehensive RS lab with focused research on precision agriculture, water safety, bioenergy, machine learning, and soil subsidence.[108] Notably, the CGI has a sensitive compartmented information facility ("SCIF") approved for geospatial work requiring security clearance.[109] CGI's SCIF can be used for secure, collaborative research with industry partners. University resources are further discussed in Trait 1, Section B(i) above.

T-REX and the Geospatial Resource and Innovation Center. T-REX has made significant efforts to grow the geospatial industry and serve as a hub of regional industry activity. T-REX is home to an NGA innovation team and a number of geospatial companies, including Geodata IT, Boundless, Engility, Optimal Geo, Radiant Solutions, and Booz Allen Hamilton. In addition to providing geospatial startups with office space and equipment access, T-REX serves as a convener or host for geospatial-centric events, including USGIF's 2018 Tech Showcase West, SLAWG meetings, and NGA events. As an ongoing initiative, T-REX and USGIF have a Memorandum of Understanding to collaborate on local geospatial objectives, including continued development of a geospatial tech talent pipeline.

In 2018, T-REX announced its development of a Geospatial Resource and Innovation Center ("GRIC") that will provide training and incubator space specifically tailored to emerging geospatial companies.[110] GRIC will have state-of-the-art equipment for geospatial work and research, including sophisticated computer equipment and access to key datasets, and it will contain classroom space for universities to provide geospatial training and certificate courses. GRIC's major goals include supporting geospatial training and education, including K-12 education and the current workforce; supporting geospatial innovation and entrepreneurship; and developing a coordinated campaign to create awareness of the St. Louis region's economic cluster and its unique strengths in geospatial and location intelligence.[111]

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[107] Sue Pollman, N2W Program Director, NGA, presentation at Aug. 2018 SLAWG meeting.
[108] Interview with Dr. Mark Brickhouse and Dr. Vasit Sagan of SLU, Aug. 10, 2018.
[109] Presentation by Dr. Curt Davis, Director of CGI, at UM System Geospatial Summit, Oct. 4, 2018.
[110] See Wayne Pratt, *T-REX prepares for big jump into geospatial innovation*, St. Louis Public Radio, May 7, 2018 (available at http://news.stlpublicradio.org/post/t-rex-prepares-big-jump-geospatial-innovation#stream/0).
[111] See T-REX One-Page GRIC Summary, presented at conference with UM System and T-REX, Jun. 29, 2018 (hereafter referred to as the "T-REX GRIC Summary").

Existing Regional Infrastructure. The St. Louis region possesses high-potential, built-out infrastructure for commercial and residential purposes, including its downtown area, affordable urban neighborhoods, multimodal transportation networks including a major airport, and world-class universities.[112] While many buildings near the N2W site are vacant or abandoned, some properties could be used or repurposed by geospatial companies hoping to establish a presence close to N2W. To spearhead this opportunity, a subgroup of SLDC's Geospatial Economic Development Workshop has agreed to form a real estate task force to identify and prioritize prime locations for geospatial development.[113]

(ii) Needs and Challenges

Lack of Gathering Space for the Geospatial Industry. Though GRIC and N2W are on the way (scheduled to open in 2019 and 2024, respectively), there is currently no central physical location for professionals in the geospatial industry to cross paths, learn from each other, and spark collaboration. Venues like T-REX and Cortex offer attractive gathering space, but there is currently no shared space with tailored equipment for cross-sector geospatial research and work.

Lack of Sophisticated Equipment Available for Industry and Academic Collaboration. Geospatial industry infrastructure largely revolves around hardware and software capabilities. As discussed in Trait 1, Section C(ii) above, geospatial research typically requires powerful computers and software capable of processing and analyzing large amounts of data, along with data storage systems able to hold those massive data troves. Much of the hardware, software, and data storage resources required for geospatial analysis is very expensive and can be difficult for small companies and researchers to obtain.

(iii) Possible Solutions

Build Out Existing Stakeholder Facilities to Provide Critical Equipment and Gathering Spaces. Existing stakeholders should consider opening select facilities and equipment to a broader, cross-sector group of geospatial researchers and industry partners. For example, similar to CGI in Columbia, Missouri, universities in the St. Louis region could explore setting up a SCIF for secure, collaborative research between industry and academia.

T-REX's GRIC will contribute by providing an environment for interactions between industry, universities, and government. At GRIC, NGA employees will have increased opportunities to collaborate with innovative geospatial companies and talented academic researchers, furthering NGA's goal of closer cooperation with industry and

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[112] See SLEDP and SLDC, *Comprehensive Economic Development Strategy for St. Louis City and County 2017-2022*, Dec. 16, 2016), at 59, (available at https://www.stlouis-mo.gov/government/departments/sldc/documents/upload/15120-CEDS-Report-Final.pdf) .

[113] SLDC Geospatial Economic Development Workshop, Sept. 27, 2018.

academia.[114] T-REX could also use the GRIC to co-sponsor training programs on obtaining government grants and contracts with the Small Business Technology Development Center.[115] To meet increased demand for collaborative research space, universities could consider partnering to provide additional space equipped for cross-sector geospatial research.

E. *Capital Access*

Simply put, entrepreneurship relies on money – emerging companies need capital to grow and expand. Raising capital can be particularly difficult for companies located between the coasts, as significant startup funding tends to be concentrated in California and the Northeast U.S. However, targeted efforts by industry cluster stakeholders can provide access to critical capital that emerging companies need to survive and, eventually, thrive.

(i) Existing Resources

Startup Funding Programs. The State and St. Louis region have a basic foundation of funding resources. In 2016, St. Louis saw an 11.5% increase in startup funding to nearly $300 million,[116] with 24.3% of all startups receiving funding.[117] While many funding sources are industry-specific (e.g. plant science, FinTech), many are industry-agnostic and would be available to promising geospatial startups. Examples include Arch Grants, a non-profit that provides non-dilutive funding to startups, Cultivation Capital, which supports and invests in startups through multiple funds and programs, and ITEN, which connects startups to potential funding sources.[118]

Missouri Technology Corporation. The Missouri Technology Corporation ("MTC") is a State-owned nonprofit created to support entrepreneurs and emerging companies. MTC invests in startups and entrepreneurial support organizations in Missouri through grant programs including Missouri TechLaunch, the Seed Capital Co-investment Program, and the Missouri Building Entrepreneurial Capacity Program ("MOBEC"). MTC has played a key role in advancing early-stage technological innovation throughout the State in industries such as animal health, applied engineering, biomedical science, defense and homeland security, and plant science. And on the geospatial front, MTC has provided $200,000 in MOBEC funding to help develop T-REX's GRIC.

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[114] See *id.*; see also Colin Clark, *Cardillo: 1 Million Times More GEOINT Data In 5 Years*, Breakingdefense.com, Jun. 5, 2017 (available at https://breakingdefense.com/2017/06/cardillo-1-million-times-more-geoint-data-in-5-years/).

[115] See *id.*

[116] See Brian Matthews, *St. Louis Venture Firms Raise $290 Million of Venture Capital in 2016*, Entrepreneurial Quarterly St. Louis, Jan. 13, 2017 (available at http://eqstl.com/st-louis-firms-raise-290-million-venture-capital-2016/).

[117] See St. Louis Economic Development Partnership and St. Louis Development Corporation, *Comprehensive Economic Development Strategy for St. Louis City and County 2017-2022*, Dec. 16, 2016, at 34; see also T-REX, *Supporting Geospatial Innovation and Entrepreneurship in St. Louis Missouri*, Aug. 2018.

[118] See T-REX, *Supporting Geospatial Innovation and Entrepreneurship in St. Louis Missouri*, Aug. 2018.

(ii) Needs and Challenges

Lack of Late Seed Financing. While the State and St. Louis region has significant amounts of early-stage seed (~$28 million), Series A (~$110 million), and later-stage venture capital (~$130 million) investments, there is a dearth of funding for startups in between early-stage and Series A life cycles.[119]

Fewer Funding Sources for Non-Biotech Startups. Many existing startup funding sources focus exclusively or primarily on biotech – startups in other sectors often have fewer options. In 2017, over 50% of all venture capital for St. Louis startups was invested in biotech companies, and from 2008-2017, St. Louis-based FinTech and cybersecurity startups raised approximately 2.5% and 0.1% as much as their biotech counterparts.[120]

(iii) Possible Solutions

Educate Existing Investors and Entrepreneur Support Organizations about the Geospatial Industry. An intentional effort to inform existing State and regional investors and support organizations about the geospatial industry would be a good first step toward funding and better supporting geospatial startups in the State and St. Louis region. Data and growth projections from the in-depth study recommended in Trait 1, Section A(iii) could provide a compelling case for investors to target geospatial startups in the future.

Consider Establishing a Geospatial-Focused Accelerator or Support Program. A geospatial-focused accelerator could support a pipeline of geospatial startups by providing capital, tailored mentoring, access to equipment, and connections to funding sources. Potential models include the Ameren Accelerator, an innovative partnership among the UM System, UMSL Accelerate, Ameren, and Capital Innovators that assesses, mentors, and invests in energy technology startups.[121]

Trait 2: Industry-Driven, University-Fueled, Government-Funded

Cluster development initiatives require many supporters, and it all starts with industry. Industry needs drive cluster development, which must create a solutions-focused ecosystem capable of addressing those needs. Universities supply talented graduates, research, and innovations via tech transfer and commercialization. And federal, State, and local governments provide critical funding, expertise, and resources necessary to fill gaps that

[119] See Governor's Innovation Task Force Summary Report, Aug. 31, 2017, at 50; see also St. Louis Regional Chamber, *2017 Greater St. Louis Venture Capital Overview* at 7, 15 (available at http://www.stlregionalchamber.com/docs/default-document-library/stl-venture-capital-overview.pdf) (hereafter referred to as "St. Louis Regional Chamber 2017 Report").

[120] See St. Louis Regional Chamber 2017 Report at 6.

[121] See Capital Innovators website at https://www.capitalinnovators.com/ameren-energy-accelerator.

industry alone cannot address (e.g. the State's $25 million tax credit commitment to the Danforth Plant Science Center, a key enabler in instigating St. Louis's plant science cluster).[122]

Milwaukee's water technology cluster provides an excellent example of cross-sector cluster support. Cluster development efforts began when two local CEOs of water-centric companies recognized the potential synergies between many water-centric firms in the region, ranging from water purification and sewage treatment to pumping and delivery. Next, a local economic development organization hired two consultants to perform a strategic review of Milwaukee's industries, which corroborated the CEOs' findings. Later, at the industry leaders' suggestion, the University of Wisconsin – Milwaukee built a School of Freshwater Sciences with state funding. These coordinated efforts formed the building blocks for what has become a globally recognized water technology hub.[123]

(i) Existing Resources

Industry. Missouri and the St. Louis region are home to over 40 geospatial companies spanning a wide range of applications and services. Table 2 below contains a list of State and regional companies with a significant geospatial component. Notably, Monsanto (since acquired by Bayer) demonstrated its support of the St. Louis region's growing geospatial industry by awarding a $500,000 grant for T-REX's GRIC.[124]

Table 2 – Geospatial Industry Presence[125]

Ameren	Harris
Arctic Slope	InSequence
BAE Systems	Intergraph
Booz Allen Hamilton	KeyW
Ball Aerospace	Leidos
Bayer (formerly Monsanto)	Mantech
Boeing	Mitre
Boundless	NJVC
CACI	Northrup Grumman
C-Edge	OGSystems
Chameleon Integrated Services	Optimal Geo
Chenega	Radiant GEO
Civil Designs Inc.	Raytheon
Continental Mapping	SAIC
CSRA	SI Corp

[122] See Brookings Report at 35.
[123] See Brookings Report Milwaukee Case Study at 4-5.
[124] See Bryce Gray, *Monsanto awards grant for new geospatial technology center at T-REX incubator downtown*, St. Louis Post-Dispatch, Jun. 13, 2018 (available at https://www.stltoday.com/business/local/monsanto-awards-grant-for-new-geospatial-technology-center-at-t/article_de5f145e-f803-56f2-a8c5-aefab31129a4.html).
[125] See SLAWG Catalog of Resources; see also Steven Thomas presentation at St. Louis Geospatial Economic Development Workshop, May 4, 2018.

CTRC Esri Flight Safety International Garmin (KC) General Dynamics Geodata IT	Spatial Data Integration Surdex Corporation T-Kartor USA TWM Inc. Vencore World Wide Technology

University. As discussed in Trait 1 above, the State and St. Louis region have a significant amount of university-based geospatial research, courses, and capabilities across a broad array of disciplines, from defense to urban planning. See Trait 1, Sections B and C above for additional detail.

Government and Military. The geospatial industry has received significant federal, State, and local priority. Most notably, State and local government went to great lengths and committed significant financing to secure the N2W site, resulting in a projected federal investment of $1.75 billion in NGA's future St. Louis facility. T-REX's GRIC will also receive federal and State funding, including a $500,000 EDA grant from the U.S. Department of Commerce and a $200,000 grant from MTC.[126] And, as discussed in Trait 1, Section A above, State and local government organizations like SLDC and the Missouri Military Advocate have actively increased awareness and coordination to support NGA's mission and the State and St. Louis region's geospatial industry.

The State and St. Louis region are home to several military assets and federal agencies actively involved in geospatial technology:

> *Scott Air Force Base.* Scott Air Force Base ("Scott AFB") is home to the Defense Intelligence Security Agency ("DISA") and United States Transportation Command ("USTRANSCOM"), both of which are significant consumers and producers of NGA geospatial intelligence.
>
> > *USTRANSCOM.* USTRANSCOM is responsible for providing common user and commercial air, land, and sea transportation, terminal management, and aerial refueling to support the global deployment, employment, sustainment, and redeployment of United States forces. USTRANSCOM is also the distribution process owner for United States forces. USTRANSCOM's three component commands (Air Mobility Command at Scott AFB, Military Sealift Command, and Surface Deployment and Distribution Command) provide intermodal transportation. All of these

[126] Interview with Bill Anderson of MTC, Jul. 9, 2018; see also Jacob Barker, *T-Rex incubator wins federal grant for geospatial center*, St. Louis Post-Dispatch, Jun. 21, 2018 (available at https://www.stltoday.com/business/local/t-rex-incubator-wins-federal-grant-for-geospatial-center/article_03cc6b5c-4434-561a-957f-a33c15b6a84a.html).

critical functions and commands rely upon accurate and timely geospatial intelligence from NGA.

Defense Information Systems Agency. The Defense Information Systems Agency ("DISA") is a Department of Defense combat support agency that provides real-time information technology (IT) and communications support to the president, vice president, secretary of defense, military services, and combatant commands. Scott AFB is home to DISA's Global Operations Center, a 164,000-square-foot complex that houses the cyber-protection division. This division, along with other DISA elements, are charged with executing global mission support and emergency response coordination. DISA relies heavily upon timely and reliable geospatial intelligence as it provides mission support and coordination.

Fort Leonard Wood. Fort Leonard Wood ("FLW") is a major United States Army training installation located in central Missouri. FLW is home to the Army's Maneuver Support Center of Excellence and schools for engineering, military police, and chemical, biological, radiological and nuclear.[127] On the geospatial front, FLW is home to the Army's Capability Manager Geospatial ("CMG"), which is the Army Training and Doctrine Command's centralized manager for coordination, integration, and synchronization of all Army geospatial information. CMG also centralizes Army digital terrain data and geospatial service requirements for capability and force development, training, and simulation.[128]

Jefferson Barracks Air National Guard Base. Jefferson Barracks Air National Guard Station ("JBANGS") is the oldest U.S. military installation west of the Mississippi River, located only 5 miles south of NGA's current St. Louis campus. JBANGS has a long and rich tradition of supporting the nation's military campaigns and boasts several key "firsts" in U.S. military history – including the genesis of the modern cavalry and the first successful parachute jump from an airplane. Today a key component at JBANGS is a Missouri Air National Guard ("MOANG") unit that provides operational-level command and control of U.S. and coalition air forces operating in the Indo-Pacific Area of Responsibility. Working alongside active duty colleagues, MOANG professionals conduct strategic planning, direct daily air operations, and coordinate intelligence collection activities and analysis. Additional missions include civil engineering and combat communications.

NGA plays a key role in the unit's mission, providing essential geospatial intelligence and services. Additionally, its close proximity to JBANGS ensures a

[127] See MSCoE and Fort Leonard Wood Fact Sheet, available at https://home.army.mil/wood/index.php/about/mission.

[128] See TRADOC Capability Manager Geospatial website at https://home.army.mil/wood/index.php/units-tenants/USAES/Orgs/TCM_GEO.

steady stream of ready-trained specialists willing to serve the nation in uniform through the Air and Army Guard and the Air Force Reserves. New and evolving coordination with NGA includes NGA training at JBANGS facilities and the prospect of continuity of operations for key NGA functions.

United States Geological Survey. The United States Geological Survey ("USGS") is the nation's largest water, earth, and biological science and civilian mapping agency, and its National Geospatial Technical Operations Center is based in Rolla, Missouri.[129] USGS collects, monitors, analyzes, and provides science about natural resource conditions, issues, and problems. Federal agencies and the general public use USGS's information to describe and understand the Earth, minimize loss of life and property from natural disasters, manage water, biological, energy, and mineral resources, and enhance and protect quality of life.[130] USGS is an active collaborator with NGA. In 2015, the NGA and USGS signed a memorandum of understanding to establish a framework for partnership and cooperation to strengthen the NGA's and USGS's activities in support of national policy and security.[131]

Additional Stakeholders. Innovation leaders T-REX and Cortex have been strong supporters of the St. Louis region's geospatial industry, culminating in T-REX's GRIC development (see Trait 1, Section D above) and Cortex's hosting of several geospatial-focused conferences and gatherings (discussed below in Trait 5). Additionally, Arch to Park, a civic organization dedicated to developing St. Louis's urban core, has expressed a strong interest in supporting St. Louis' geospatial cluster development efforts. Arch to Park continues to engage with NGA, St. Louis, and the State in an effort to identify methods to best support a globally recognized geospatial industry hub in St. Louis. And the St. Louis Science Center is teaming up with a SLAWG subcommittee to create a geospatial exhibit designed to raise awareness of the geospatial industry and its long history in the St. Louis region.

(ii) Needs and Challenges

Need for Increased Interaction and Partnership Across Sectors. Though the geospatial industry has broad involvement from industry, university, and government sectors, apart from SLAWG meetings, there are few regular opportunities for representatives from each sector to convene in order to identify needs, discuss resources, and collectively solve problems necessary to support the geospatial industry ecosystem. Regular, systemic interaction between sectors is necessary in order to develop, coordinate, and optimize efforts to support the State's and St. Louis region's geospatial industry development.

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[129] See USGS website at https://www.usgs.gov/about/about-us/who-we-are.
[130] See *id.*
[131] See Memorandum of Understanding Between the Department of the Interior, United States Geological Survey, and the Department of Defense, National Geospatial-Intelligence Agency 2014-0035, May 13, 2015.

Lack of Industry Diversification, Siloed Industry Sectors. The St. Louis region is rich in geospatial stakeholders, but they are largely defense-oriented.[132] As such, the local industry is heavily reliant on NGA (and indirectly, federal appropriations) for a significant portion of its business. Thus, a change in federal appropriations or national defense strategy could have an outsized impact on the local geospatial industry. While the region includes commercial geospatial stakeholders in areas like precision agriculture and remote sensing, there is typically little interaction across industry subgroups.

Need for Industry Leadership. There is a need for concerted industry leadership to drive geospatial development efforts. Although geospatial companies have participated in ecosystem-building initiatives like SLAWG, such efforts are volunteer-led and occasionally have difficulty driving substantive action and committed involvement from participants.

(iii) Possible Solutions

Convene Regular Cross-Sector Roundtables. In order to foster an understanding of needs and resources across industry, university, and government, a convening organization could assemble recurring small group roundtable discussions with key representatives from each sector. Cortex and SLU's TTSI provides a good model for such discussions – a moderator can structure discussion between a small group of individuals with insight into each sector and the ability to direct their organization's resources, all with the shared goal of building up the State's and St. Louis region's geospatial industry ecosystem. SLAWG, T-REX, or Cortex could all serve as potential conveners.

Build a Collective Voice for Industry. The State and regional geospatial industry must effectively aggregate and convey its needs to university and government partners, and then work with those partners to support the industry. Just as crucial, university and government partners must be responsive and solutions-focused, dedicated to meeting industry needs. Cluster development is premised on addressing industry needs, and it cannot happen unless university and government partners adequately understand them. The State and local geospatial industry could potentially accomplish this through SLAWG. Additionally, the formation of a State/regional geospatial industry council with dedicated staff could provide an additional vehicle to convey industry interests.

Trait 3: Place a Collective Big Bet on a Unique Opportunity

Significant investment in a specialized, identifiable, highly relevant industry can help a region stand out from the pack. Focusing on one unique cluster can serve to open up new opportunities in other industries through common infrastructure, research areas and labor skills. For example, an inland port developed primarily for South Carolina's automotive

[132] Interview with Eric Druker, Director of Artificial Intelligence, BAH, Sept. 4, 2018.

cluster had significant spillover benefits for other industries that required shipping access.[133] As Tim Nowak of St. Louis' World Trade Center explains, a premier industry cluster such as ag tech serves as the "tip of the spear" for FDI and business recruitment efforts.[134]

(i) Existing Resources

Winning N2W. The State and St. Louis region made a "big bet" on the geospatial industry through their concerted efforts, which culminated in NGA's decision to locate N2W in north St Louis. These efforts required a massive investment of financial resources and staff time (still ongoing, as SLDC prepares to deliver the cleared, remediated N2W site for development in November 2018).

GRIC. T-REX has made a significant bet in geospatial industry development through GRIC, a first-of-its-kind geospatial resource center. Industry and government partners have contributed grant money to support the effort, and NGA has indicated strong interest in partnering with GRIC.

(ii) Needs and Challenges

What Next? Following the N2W decision, there are few clear "next steps" to best support the State's and St. Louis region's geospatial industry. While several organizations have indicated their interest in supporting the geospatial industry, they need guidance in order to best direct and coordinate their efforts to distinguish the St. Louis region as a globally recognized center for the geospatial industry.

(iii) Possible Solutions

Insights from In-Depth Study and Recommendations. The in-depth, independent study discussed in Trait 1, Section A above could identify the most critical areas for large-scale investment to support the geospatial industry. Private and public stakeholders interested in growing the industry could coalesce around such study's recommendations and take concerted steps to implement them, similar to the Battelle study that has guided development of St. Louis' plant and life science clusters for nearly 20 years.

Trait 4: Championed by Passionate, Dedicated Leaders

Successful cluster development initiatives start with individuals ready and able to champion the cause. This point was underscored in a 2003 Battelle report prescribing a statewide framework to develop Missouri's life sciences industries. The report stressed that "Implementing the Missouri life science strategy will require both staff and resources. One

[133] See Brookings Report at 35-36.
[134] See *id.*

or more entities must be designated to take the lead on implementing the various initiatives proposed in the strategy, and an organization must be given responsibility for overseeing overall implementation. […] *Studies of strategic planning suggest that a critical success factor is the presence of a champion who has the ability to bring together key stakeholders and mobilize various institutions to implement the strategy*."[135]

Cluster development leaders often come from businesses within the cluster, as with Milwaukee's water technology cluster (originally spearheaded by two CEOs of water-focused companies).[136] And some leaders emerge from outside the industry, such as Dr. William Danforth, the former WUSTL chancellor who spearheaded the development of St. Louis' plant and life science clusters.[137] Regardless of their origin, cluster leaders must be able to effectively convey the cluster vision, build an intimate knowledge of the industry, and mobilize stakeholders and resources to keep development rolling.

(i) Existing Resources

Broad-based Efforts. Thus far, State and regional geospatial cluster development has consisted of multiple stakeholders taking ownership of different areas of ecosystem development. Many organizations in the State and St. Louis region have devoted significant time and resources to support geospatial cluster growth, most notably SLDC (Geospatial Economic Development Workshops), T-REX (GRIC), and SLAWG. At the individual level, Steven Thomas of Ball Aerospace and former NGA West Executives Steve Wallach and Bobbi Lenczowski have played a significant role in raising awareness of St. Louis' geospatial cluster potential.

(ii) Needs and Challenges

Need for Champions. The St. Louis region has a wealth of geospatial resources and ongoing initiatives, but it lacks individual leaders with the time and ability to drive cluster development forward. Organizational efforts have been strong and continue to keep momentum going, but they need clearly identified leaders to convey vision and coordinate stakeholders' efforts towards cohesive long-term cluster development. The State and St. Louis region have many existing geospatial resources and initiatives, but these components must connect, complement, and strengthen each other in order to build a globally recognized center of excellence for the geospatial industry. With so many geospatial efforts underway, there is a significant need for one or more central stakeholders to make sure other stakeholders are aware of such efforts and can complement them accordingly, avoiding unnecessary duplication or competition.

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[135] See Technology Partnership Practice, Battelle Memorial Institute, *Life Sciences & Missouri's Economic Future: An Opportunity to Build "One Missouri"*, prepared for the State of Missouri, the UM System, the Danforth Foundation, and the Ewing Marion Kauffman Foundation, Jan. 2003, at xxix – xxx (emphasis added).

[136] See Brookings Report Milwaukee Case Study at 4-5.

[137] See Brookings Report at 36.

(iii) Possible Solutions

Form a Cross-Sector Coalition of Leaders. A small group of key leaders from industry, academia, and government could form to lead the St. Louis region's geospatial cluster development.

New Entity. St. Louis's successful plant and life science clusters present a possible model. Prior to the Battelle Study, a small group of individuals from industry, academia, and nonprofit institutions championed regional efforts to commission an independent in-depth study of the region and the industries, convened a group of core stakeholders around the study, and provided input into which organizations and individuals could implement the study's findings. The core group consisted of individuals who were widely respected across the State and St. Louis region and had the ability to raise and direct the resources necessary for the cluster initiatives' formative stages.[138] Similarly, a group of respected community leaders from industry, academia, government, and nonprofit institutions could form a leadership entity to coordinate and implement regional geospatial industry development.

Existing Entity. Alternatively, an existing entity could take initiative or be authorized or commissioned to underwrite an independent study or coordinate its implementation. For example, the Battelle Study was underwritten in part by the St. Louis Regional Chamber. A similar entity could spearhead an independent study for the geospatial industry to optimize cluster development.

Dedicate Existing Stakeholder Resources and Staff to Geospatial Industry Development. In the absence of a formal leadership coalition or entity, local geospatial industry development would greatly benefit from individuals at existing innovation, economic development, and government stakeholder organizations who can build geospatial expertise and prioritize cluster development. Though current stakeholder organizations have been actively involved in cluster development, it is typically one of many priorities and takes a backseat to impending contract bid deadlines, unforeseen crises, and other necessary industry, academic, and government functions. Staff members with a consistent, sustained focus on building the St. Louis region's geospatial industry ecosystem could enhance coordination between stakeholders to optimize the various, ongoing geospatial initiatives towards cohesive, long-term cluster development.

Two organizations have indicated their intent to hire geospatial-centric staff. In late 2018, T-REX will hire a full-time Geospatial Coordinator to lead its geospatial program and serve as a representative for the local industry.[139] Additionally, SLDC has joined T-REX to apply for a grant that would fund a geospatial project manager position within SLDC. This

[138] See BioSTL, *History*, available at http://www.biostl.org/about/history/.
[139] Correspondence with Patty Hagen of T-REX, dated Sept. 24, 2018.

position's responsibilities would include, but not be limited to, serving as liaison between the City and the local geospatial community, interacting with NGA and geospatial companies to better understand and meet their needs, and shepherding implementation of recommendations that an in-depth study similar to the Battelle Study would produce.[140]

Trait 5: Anchored by a Physical Center

Many successful clusters pride themselves on a physical hub of industry activity where representatives from established industry, emerging industry, academic researchers, and others can interact and collaborate on a daily basis. Such centers have a powerful branding effect as well, validating a region's status as a hub of industry activity. Physical centers can consist of a single building or a larger district or campus.[141] Examples include St. Louis' 39 North District, Milwaukee's Global Water Center, and South Carolina's Clemson University – International Center for Automotive Research (CU-ICAR) campus.[142]

(i) Existing Resources

N2W. Upon its scheduled opening in 2024, N2W will be the most visible center for geospatial activity in St. Louis. The new facility is set to have 20% of its space reserved for flexible use and 20% of its space reserved for sensitive but unclassified research and collaboration, which will result in a potential joint research hub.

T-REX and GRIC. As discussed in Trait 1, Section D(i) above, T-REX has served as a focal point for many geospatial activities and houses an NGA team and several geospatial companies. Upon its completion, GRIC will be a key center for geospatial collaboration between individuals from industry, academia, NGA, and elsewhere. Additionally, it will likely be easier for the public to access T-REX and GRIC than the highly-secure N2W facility – the GRIC will not house classified work and will not require stringent security measures that could impede community and stakeholder access.

Cortex. Cortex has emerged as a valuable cross-sector nexus between startups, established companies, academia, professional service providers, and government organizations to form relationships and exchange ideas. On the geospatial front, Cortex has hosted industry events like the inaugural GEOx, a geospatial technology showcase co-sponsored by NGA, USGIF, and EVNTUR,[143] and the inaugural GeoYou Conference, a gathering of geospatial industry professionals sponsored by the American Society for

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[140] See T-REX, *Supporting Geospatial Innovation and Entrepreneurship in St. Louis Missouri*, Aug. 2018.
[141] See Brookings Report at 36-37.
[142] See Brookings Report Case Studies of St. Louis, Milwaukee, and Upstate South Carolina.
[143] See Cortex, *Cortex to Host First GEOx Geospatial Technology Showcase*, Oct. 17, 2016 (available at https://cortexstl.com/cortex-to-host-first-geox-geospatial-technology-showcase/).

Photogrammetry and Remote Sensing and focused on big data and real-time analytics.[144] Cortex has a history of supporting the geospatial industry and will likely continue to convene geospatial industry professionals across the St. Louis region.

(ii) Needs and Challenges

Classified NGA Facility. N2W must meet federal security requirements, which could make it difficult or time-consuming to enter the facility. For example, entering NGA's current St. Louis facility requires advance clearance, security screening, and leaving electronics outside of the facility. Additionally, most of N2W will be designated for classified work and will require a security clearance to enter, posing a challenge for connectivity between NGA and the community. Though N2W could serve as an obvious center of the region's geospatial cluster, it will have to navigate significant security requirements to become accessible to non-NGA stakeholders.

Decentralized. The St. Louis region's upcoming geospatial facilities will provide great collaborative spaces, but the closest points (N2W, T-REX, and Cortex) will each be over a mile away from each other. Additionally, geospatial companies and academic resources are spread out over the State and region, stretching north (Boeing in Hazelwood), south (General Dynamics IT in south St. Louis County), east (Scott Air Force Base near O'Fallon, Illinois), and west (the UM System's CGI in Columbia, Missouri). The distance between geospatial stakeholders makes it difficult to spark regular interactions and collaboration.

(iii) Possible Solutions

Consider Physical Connections Between Existing and Future Facilities. As part of a larger set of local economic development strategies, economic development stakeholders should prioritize "connecting the dots" between N2W, T-REX, and Cortex through various types of infrastructure and transportation. Possible options could include bicycle and walking paths, bus routes, and a larger development strategy along each route.

Encourage a Centralized Presence from Existing Geospatial Stakeholders. Though many of the State's geospatial stakeholders are geographically dispersed, they could locate key resources in a centralized location. The developing partnership between T-REX and the UM System provides a prime example, as the UM System explores locating select geospatial courses and certificate programs in T-REX's GRIC. Additional academic stakeholders could follow suit by locating programs locally, and industry partners could

[144] See GeoYou website, available at https://geoyou.org/about/; see also Jacob Barker, *Inaugural GeoYou Conference is latest to convene geospatial talent at Cortex*, St. Louis Post-Dispatch, Sept. 12, 2017 (available at https://www.stltoday.com/business/local/inaugural-geoyou-conference-is-latest-to-convene-geospatial-talent-at/article_5fba3723-c35b-5d04-b29f-2822c5db23e5.html).

consider opening branch offices, housing employees in co-working space, and developing an active presence closer to the future N2W site, T-REX, and Cortex.[145]

SECTION III

CONCLUSION

The State and St. Louis region are rich in geospatial resources, including the NGA and major industry, academic, government, and other stakeholders. The St. Louis region's geospatial ecosystem exhibits many of the key traits ascribed to successful industry clusters around the country, especially ample involvement from many stakeholders. But to move forward and maximize success, cluster development efforts must address a number of challenges, including a need for increased stakeholder coordination, identifiable leaders to guide overarching cluster development efforts, and an increased awareness of the St. Louis region's significant geospatial assets. In addition, an in-depth, independent study and recommendations similar to the St. Louis region's successful development plan for the life science and plant science industry clusters would be a critical enabling step.

[145] See, e.g., William R. Kerr, *Navigating talent hot spots*, Harvard Business Review, Sept. 26, 2018 (available at https://www.bizjournals.com/stlouis/news/2018/09/26/hbr-navigating-talent-hot-spots.html).

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